VOLUME XXX NUMBER 4 WHOLE NUMBER 253

THE JOURNAL

OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR
C. A. CHANT
David Dunlap Observatory
Richmond Hill P.O., Ont.

ASSOCIATE EDITORS
R. MELDRUM STEWART
Director of the Dominion Observatory
Ottawa

W. E. HARPER
Director of the Dominion Astrophysical Observatory, Victoria, B.C.

J. PATTERSON
Director of the Meteorological Service of Canada, Toronto

PUBLISHED MONTHLY
(*Ten numbers per year*)

April, 1936

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

Vol. XXX, No. 4 APRIL, 1936 Whole No. 253

Articles Page

The Temiskaming Earthquake of November 1, 1935. The Location of the Epicenter and Determination of Focal Depth (With plates VII-XIII) - - - - - *Ernest A. Hodgson* 113
Note on Nova Herculis - - - - - *W. E. Harper* 124
The Architecture of a Star - - - - - *R. M. Petrie* 127
The Astronomer Looks for Life in the Heavens - *R. M. Petrie* 131
Radio Talks over CFCT, Victoria B.C.
No. 81. The Crust of the Earth - - *W. E. Harper* 136

Meteor News
Nebulous Meteors; Two Bright Fireballs - - *P.M.M.* 139

Review of Publications
Stars and Telescopes, by James Stokley (*C.A.C.*); Let's Look at the Stars, by E. B. Frost (*W.E.H.*) - - - - - - 143

Notes and Queries
Not a Foreign Country (*C.A.C.*); Error in the 1936 *Handbook* 145

Meetings of the Society
At Toronto—At Vancouver - - - - - - - - - 148

Upon request, made previous to publication of article, contributors will be supplied free either with fifty copies of the issue containing the article, or with the sheets containing the article attached to a printed cover. If separate reprints are desired the cost will be as follows:

	4 pp.	8 pp.	12 pp.	16 pp.	20 pp.	24 pp.
50 copies	$3 50	$5 50	$ 9 50	$10 00	$13 00	$16 00
100 copies	4 00	7 00	10 00	11 00	14 00	18 00
200 copies	4 50	8 00	11 00	12 00	15 50	20 00

Covers, extra, 50 copies, $1.50; 100 copies, $2.00; 200 copies, $2.50.

Business correspondence, remittances, etc., should be addressed to J. H. Horning, Treasurer of the Society, 198 College Street, Toronto.

Communications regarding Library matters should be addressed to the Librarian.

$2.00 per annum. Single numbers, 25 cents.

Subscription to the Journal is included in membership fee.

Amateur Telescope Makers may obtain crown glass discs, achromatic objectives, diagonals and eyepieces, abrasives, pitch, rouge, chemicals, brass bar and tubing, in good quality at reasonable prices, from Anglo-Canadian Importing Co., 510 Westminster Trust Bldg., New Westminster, B.C.

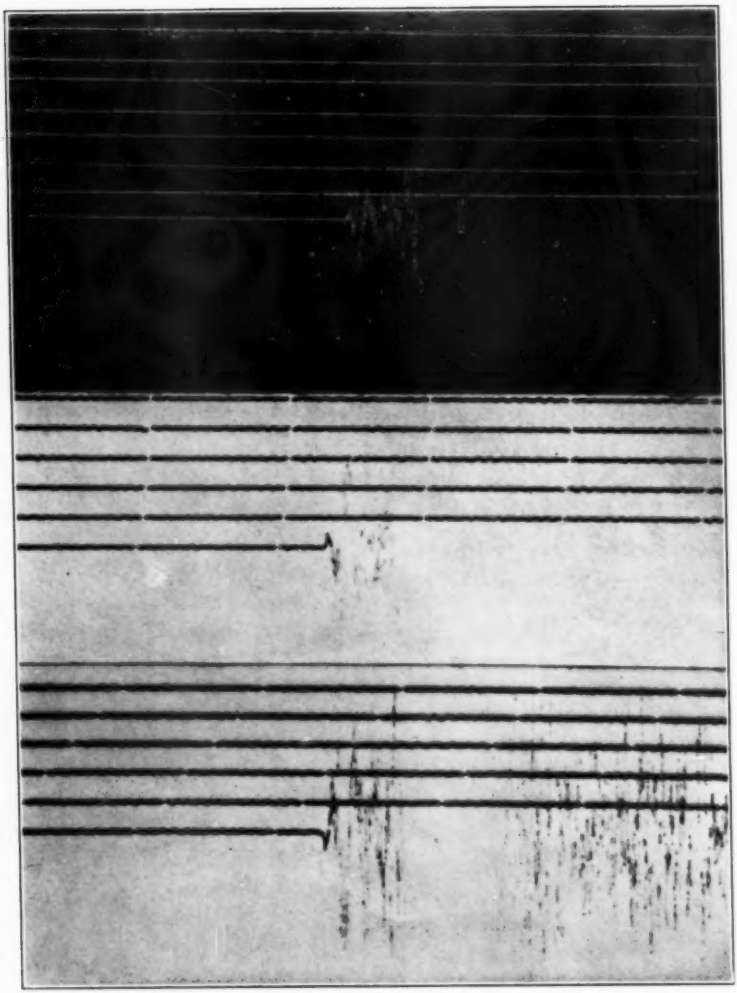


Fig. 2. Ottawa seismograms of the Timiskaming earthquake, November 1 1935. (Vert. N-S and E-W components)

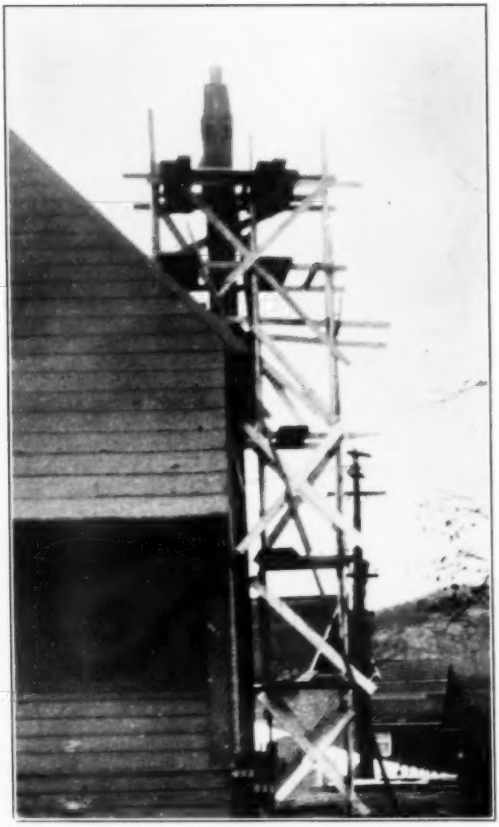


Fig. 4. "Mushroomed" chimney, Timiskaming.
(Photo by courtesy of Mr. A. K. Grimmer)

Fig. 5. Sand cracks at Boom Camp near Timiskaming

Fig. 6. Rock fall on shores of lake Kipawa

Fig. 7. North-east corner of Hunter's Lodge, displaced toward WSW

Fig. 8. Scratches on rock surfaces near Kipawa, accepted as evidence that the rocks had moved

Fig. 9. Spare rails at mileage 47 C.P.R. near Kipawa, showing displacement of about .6 in. to the SW (to left on supports as shown)

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

Vol. XXX, No. 4 APRIL, 1936 WHOLE No. 253

THE TIMISKAMING EARTHQUAKE OF NOVEMBER 1, 1935. THE LOCATION OF THE EPICENTRE AND DETERMINATION OF FOCAL DEPTH.

By ERNEST A. HODGSON

(With Plates VII-XIII)

CLOSELY following the time-honoured festivities of Hallowe'en and breaking in upon the first quiet hours of All Saints Day, the Timiskaming earthquake disturbed, to varying degrees of intensity, an area of between 500,000 to 800,000 square miles. It was felt from the Atlantic to Winnipeg and from the Carolinas to, presumably, the Arctic. In spite of the great area affected, the damage caused was very slight. One might even say that, for the most part, the damage to structures was merely a peremptory demand for safety measures previously neglected—neglected in many cases because, till then, the need had not become evident.

Except for the great area affected, the earthquake presents no spectacular features. Its chief interest appears in its scientific aspects. These, for some months to come, will form the subject of research by the Seismological Division of the Dominion Observatory, Department of the Interior, Ottawa. Enough is known to make possible the assertion that the study will likely yield results of considerable scientific value. Up to the present, the most interesting phase of the investigation has been the location of the epicentre and the determination of the depth of focus.

The *focus* of an earthquake may be defined, rather loosely, as that point within the earth from which the energy radiated. The *epicentre* is that point on the surface of the earth vertically above the focus,

that is to say, at the surface end of the radius passing through the focus. In no case, of course, can the focus or the epicentre be strictly defined as above for neither is a *point*. The former is a volume of greater or less extent and the latter an area. One may, however, select some point in the focal volume as its centre and define that point as the focus and in the same way define some central point in the epicentral area as the epicentre.

Until quite recently—the past decade—earthquakes were generally supposed to originate at focal depths of the order of twenty-five miles or less. True, some seismologists, on the basis of various lines of study, had assigned greater depths than this to some earthquakes but their deductions were accepted only with reservations by most of their colleagues. Beginning about fifteen years ago, the late Prof. Turner, working at Oxford with the reported seismological data supplied by the various stations of the world, began to find that some earthquakes were registered in their antipodal region much too soon and in their epicentral region much too late to fit in with the best time-distance table then available. One evident explanation is that the focus of these earthquakes lies abnormally deep—the depth being an appreciable fraction of the earth's radius.

Turner[1] began to classify earthquakes as "deep-focus", "normal-focus", and "shallow-focus" types. That is to say, designating certain earthquakes which best fitted the then accepted time-distance tables as normal-focus, others could be classed as deep-focus and others again as shallow-focus. The hypothesis that some earthquakes might originate at very considerable depths of the order of 700 to 800 km. was indicated as possible and this suggested investigations which should be undertaken.

Much research on deep-focus earthquakes in Japan has been done for some years by Prof. K. Wadati[2]. The investigation of such earthquakes has been greatly assisted of late years by studies which have improved the time-distance tables. These improved time-distance tables, in turn, have assisted in further research on the problem of deep-focus earthquakes by Dr. V. C. Stechschulte, S.J.,[3] Dr. F. J. Scrase[4], and others. Each step forward in the precision of locating the focus and epicentre of a well-defined earthquake tends to improve the time-distance tables; these in turn permit further

advances in the determination of epicentres and in studies of focal depth; and so forward cycle after cycle.

Several years ago Rev. George J. Brunner, S.J., working in the Geophysical Laboratory of Saint Louis University under the direction of Rev. James B. Macelwane, S.J., became much interested in the preparation of time-distance tables for earthquakes of various focal depths. Such tables had been prepared before, notably by Dr. A. Mohorovičić and his son, but, being based on poorly-defined data, the earlier tables were not found useful in practice. The studies at Saint Louis were based on modern improved tables and made use of data from seismograms recorded by the much more sensitive instruments of today. The accurate timing now made available by radio also permitted a revolutionary improvement. Furthermore, Father Brunner made the tables much more useful in routine work by plotting them as curves so designed that, accepting the curves as accurate and the observed arrival times of various phases on the seismogram as properly identified and timed, one could, by a single, simple inspection, determine the epicentral distance, the focal depth, and the focal time of any earthquake, from the records at a single station.

In Fig. 1 is shown a small area in the lower left-hand corner of the Brunner chart of Depth, Time, and Distance for Deep-Focus Earthquakes[5]. This chart was published in 1935 and had been received at the Dominion Observatory only a few weeks previous to the earthquake of November 1. Further reference will presently be made to the chart.

Before leaving this part of the discussion, it may be said that no one, least of all the authors of the chart, would claim that these time-distance curves are correct in all details. They are, however, so accurate, that, as we shall show, they evidently do permit another step up in locating the focus and epicentre of a well-defined earthquake and this in turn should yield improvements in the tables—a further progress in this cut-and-try method by which seismologists gain precision in their data, upon which are to be based deductions as to the structure of the earth's deep interior.

The above long preamble is quite necessary if one is to have a full appreciation of the really interesting aspects of the Timiskaming

earthquake to date—the procedure by means of which those investigating the data were led, step by step, to an unusually well-defined location of the epicentre and focus. Let us now return to this, our subject proper.

The seismograms, removed from the instruments within half an

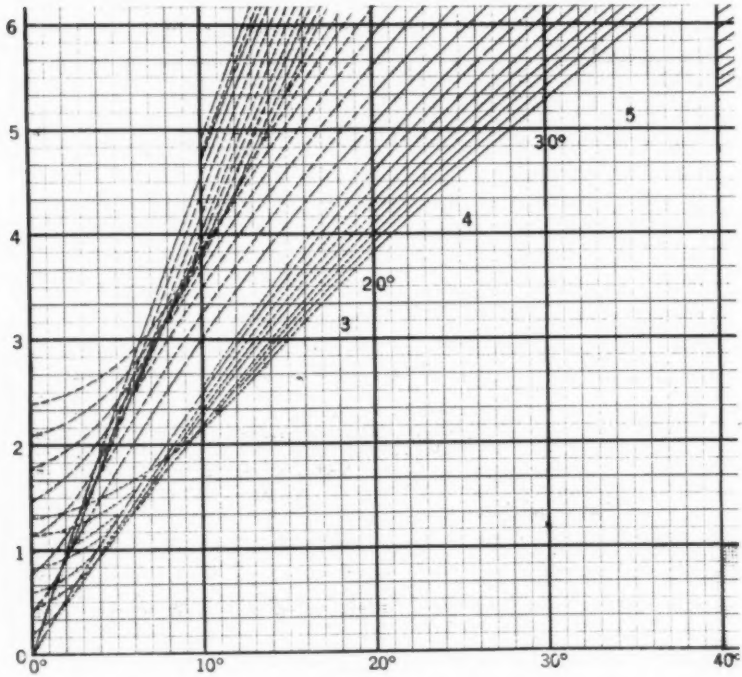


Fig. 1. Section of the Brunner Chart of Depth, Time and Distance for Deep-focus Earthquakes

hour after the disturbance began to record at Ottawa at 1h 04m 20s E.S.T., are shown in Fig. 2. The first one was recorded by the vertical component, the second by the north-south component, and the third by the east-west component. Confining our attention to the first movement recorded on each, we see that the top one shows

an initial movement down, the second shows that movement recorded by an upward shift, and the third seismogram records it down. These, being interpreted, indicate that the first movement was a thrust away from the epicentre and that, in response to this thrust, the earth at Ottawa moved almost exactly south-east. The origin of the shock must therefore have been north-west of Ottawa.

A further study of the records shows a recrudescence of energy about thirty-four seconds (a little more than half the distance between successive minute breaks on the record) after the first impulse. This is to be interpreted as indicating that the epicentre was roughly 175 to 200 miles from Ottawa.

On the basis of these records alone, then, the Observatory issued a statement about 3.30 a.m. on Friday, November 1, to the effect that the epicentre was probably in the upper Ottawa valley at a distance of from 175 to 200 miles.

If the first movement on the vertical record had been down, the indicated azimuth would have been turned through 180° and the indicated epicentre would have been in the lower Champlain valley in New England. In view of the fact that the first movement on the vertical was, as can be seen, somewhat indefinite and that the New England area seemed a much more likely place for the epicentre than the upper Ottawa valley, the New England location was given as an alternative interpretation but the note made it clear that the readings of the instruments indicated the location to the north-west.

During Friday and the early hours of Saturday, news items poured in to Ottawa and were relayed to the Observatory by the Canadian Press. It was decided that a field study of the earthquake should be undertaken. At this time came the news of a slump of some two hundred feet or more of railway on the Canadian National at Parent, Que. Now Parent is north and a little east of Ottawa and this damage apparently contradicted the azimuth given by the seismograms. It was decided to obtain further seismological data before undertaking the field study.

On Saturday, November 2, in response to requests sent to Harvard and to Science Service, Washington, D.C., the first arrival times were obtained for the seismological stations at Harvard, Georgetown (Washington), Buffalo, Chicago, and Saint Louis. These arrival

times were supplemented by that at Ottawa and on Saturday evening by that for Shawinigan Falls, Que. Seven first arrival times, probably correct in each case to the nearest second, were thus available on which to base a location.

Obviously, the nearer to the epicentre a station lies, the earlier must be the arrival time of the first impulse at that station. To locate an epicentre and determine the depth of focus on the basis of first arrival times at a number of stations, we must have a reliable time-distance table or graph. Referring again to Fig. 1, we have before us the Brunner chart. If an earthquake occur at the surface, the focus and epicentre coincide and, when the focal time (the ordinate) is zero, the epicentral distance (the abscissa) is also zero. Thus the curve for zero focal depth passes through the origin of co-ordinates. This time-distance graph is the dot-dash line which passes through the origin of co-ordinates and comes out at the top of the section shown, at a point a little short of 30°. If an earthquake originate at a focal depth of 100 km., it will take a little more than ten seconds for the first impulse to reach the epicentre. Thus the graph for an earthquake of 100 km. focal depth cuts the axis of ordinates at a point a little more than a sixth of a minute up. But at an epicentral distance of 30° the first impulse will arrive earlier for an earthquake of this depth than for one at zero depth. Thus the curve for the earthquake now considered crosses the one we first examined and emerges at the top of the section a little to the right of the 30° ordinate. So, in succession, we have the curves for the first impulse for earthquakes of focal depth 0, 100 km., 200 km., 300 km., 400 km., 500 km., 600 km., and 700 km. We may ignore the other curves on the chart.

Given the Brunner chart and the first arrival times at the seven seismological stations, we first decide on some reasonable value for the focal time and on some particular depth curve. Then, subtracting the assumed focal time from the observed arrival time for each station we obtain a value for the travel time to that station. The adopted curve gives us at once a value of the distance from the epicentre to the station concerned. In this way we obtain seven distance values. Each distance value may be used as the radius of a distance circle about the station concerned. The epicentre must lie

on each of these circles and hence, if our assumptions have been correct, these circles must intersect in a point which defines the epicentre. The plotting is done on a stereographic projection.

If the first trial does not give a good intersection, the assumed focal time or the assumed focal depth, or both, are varied and the work repeated until a satisfactory point intersection is obtained. Briefly, it may be said that after many trials with various travel-time

Fig. 3. Sketch map of the epicentral area of the Timiskaming earthquake

curves for shallow-focus earthquakes the attempt to locate this earthquake as of that type was abandoned and various depth curves of the Brunner chart were tried. Finally on Sunday afternoon, November 3, a point location was obtained for an assumed focal time of 1h 03m 40s and a focal depth of 200 km. (125 mi.). This location was at ϕ 46° 45′ N., λ 79° 15′ W., about 6 miles WNW of the town

of Timiskaming, Que. Work in the field could now be undertaken with the view of checking the location by means of field observations.

The seismologist left Ottawa at 1:20 a.m. Monday, November 4, and returned Tuesday evening, December 3. The greater part of the time was spent in the vicinity of Timiskaming. In Fig. 3 we have a sketch map of the epicentral area as determined by the field work. Evidence, which we shall give in some detail presently, is strong to support the deduction that the earthquake happened approximately north of Timiskaming. The weight of evidence is rather in favour of a location to the north-east than either to the north or north-west. The evidence is practically conclusive that the epicentre lies south and west of the C.P.R. track running from Kipawa to Dozois. The position adopted on the basis of the field work is at ϕ 46° 47′ N., λ 79° 04′ W. This point is almost exactly 9 miles east and north from that determined at Ottawa on the basis of the arrival times at the seven stations. It is almost exactly north-west of Ottawa and at a distance of 185 miles, which accords well with the location obtained within a couple of hours of the earthquake from the records at Ottawa alone. We conclude that the focal depth of 200 km. and the focal time of 1h 03m 40s are approximately correct in each case.

Request has been made to all the seismograph stations of the world for the loan of their records of this earthquake. These are being received at the time this paper is being written. When they are in hand, a study will be made of all the data there disclosed. With regard to the subject at present considered, it may be said that the position finally adopted for the epicentre, and the values adopted for the depth of focus and for the focal time will be such as to conform most satisfactorily to the observed data. The agreement so far for the three values is extraordinarily good. It is not believed that changes of any considerable magnitude will have to be made in the assumed focal time and focal depth in order to bring all observed data into accord with respect to an epicentre at or very near (within three or four miles at most) that adopted on the basis of the field work.

This, then, closes the account of the methods used and the results attained in the matter of locating the epicentre and determining the depth of focus of the Timiskaming earthquake. It remains, how-

ever, to indicate briefly the lines of investigation followed in the field work and to present some details of the evidence upon which the deductions as to the epicentral position were made.

The area of greatest destruction was found to lie close to Timiskaming, Que. The great majority of the houses in this town are unusually well built. The chimneys are lined with tile and capped with cement. About eighty per cent of these chimneys were damaged to a greater or less extent. Evidently the thrusts were almost vertical as shown in Fig. 4. Very little other damage was caused though many of the houses are of brick veneer construction. Some cracks developed in solid brick walls and one ten-inch water pipe was broken but the latter was old and not very strong. Where heavy objects in Timiskaming rested on smooth level surfaces they shifted generally to the north-north-east indicating the direction from which the thrusts came. A man working on a steel tower about 160 feet above the ground stated that the first intimation he had of the earthquake was a roar which gradually emerged above the usual noise of the tower. Then the tower swayed violently a couple of times toward the north and immediately afterwards it was swayed in an east-west direction. These observations indicate an epicentre north and perhaps a little east of Timiskaming.

Most of the ground near Timiskaming is rocky. Where gravel or sand are found and where relief is afforded at the side as on the borders of lakes, edges of islands, around gravel pits, etc., cracks appeared. Fig. 5 shows a typical crack—one of a series which ran along beside lake Timiskaming for some 200 feet or more. This picture was taken a week after the earthquake. The crack is in sand. A stick was easily pushed into the crack to a depth of three feet. The width of the crack at the top is from two to three inches as indicated by the glove.

Around lake Kipawa the gravelly and rocky shores were disturbed. The most spectacular fall is shown in Fig. 6. The great block of rock fell about 200 feet. But it was about ready to fall, as indicated by the weathered surface of the stone face from which it fell.

Hunter's Lodge, shown in Fig. 3, is a well-built log cabin. It stands on the broad flat top of a stone and cement foundation. The

house shifted bodily to the WSW. The shift from the NE corner is shown in Fig. 7.

Considerable care was exercised in examing all rocks in the epicentral area which might be expected to indicate the direction from which the thrusts came or the intensity of the thrusts. Most of the rocks had not moved at all as evidenced by the unbroken contact of lichens and mosses. Fig. 8 shows the scratches made by the slipping down of a wedge of rock when the earthquake swayed the large rock at the top of the picture. Such evidence was sought to confirm the movement of unstable rock masses. No such movements were found at distances greater than about 20 miles from the epicentre. The slide at Parent, Que., was evidently just ready to go, the earthquake acting as a sort of trigger. This is deduced from the fact that the slide is 190 miles distant from the epicentre and that the delicately balanced rocks in rock cuts near the slide at Parent were not disturbed.

In Fig. 9 we have an illustration of the type of evidence which permits the conclusion that the epicentre certainly lies south and west of the Kipawa-Dozois section of the C.P.R. The spare rails at the various mile posts are well set up on solid, heavy wooden standards. They had been in position undisturbed for about two years. The amount by which they were shifted could be learned from the rust marks on the standards and, on looking beneath the rail, by the unrusted rail section which formerly rested on the wood. The picture shows the shift at mileage 47. The 935-lb. rails moved .6 in. to the left. Referring to Fig. 3, we may say that the rails at mileage 45 shifted north-west and across the standards to the south-west; those at 46 did not shift as the standards were slightly tilted; those at 47 shifted directly across the standards to the south-west; those at 48 shifted south-east and across the standards to the south-west. Those at mileages 49, 50 - - - 54 did not shift at all.

In closing, we may refer to the aftershocks. These were felt almost all night on November 1 following the earthquake by those living within ten miles or so of Timiskaming and Kipawa. Aftershocks are still (Jan. 9, 1936) being felt in that area. The evidence of the aftershocks strongly supports the field location adopted as does too the discolouration shown by the normally clear water of T- lake.

This lake was clear, up to the night of the earthquake. When observed on Saturday, November 2, it was the colour of milky coffee and it so remained for at least a month. The water is very deep. The epicentre is believed to be close to the north-west corner of this lake.

REFERENCES

[1] TURNER, H. H., "On the Arrival of Earthquake Waves at the Antipodes and on the Measurement of the Focal Depth of an Earthquake," *Monthly Notices of the Royal Astronomical Society, Geophysical Supplement*, Vol 1, No. 1, 1-13, London, March, 1922.

———"Further Note on the Depth of Earthquake Foci," *Ibid.*, Vol. 1, No. 2, 50-55, January, 1923.

———"Shallow and Deep Earthquakes," *Geophysical Magazine*, Vol. 2, No. 3, 179-187, Tokyo, November, 1929.

[2] WADATI, KIYOO, "Shallow and Deep Earthquakes," *Geophysical Magazine*, Vol. 1, No. 4, 161-202, Tokyo, March, 1928.

———"Shallow and Deep Earthquakes (Second Paper)," *Ibid.*, Vol. 2, No. 1, 1-37, March, 1929.

———"Shallow and Deep Earthquakes (Third Paper)," *Ibid.*, Vol. 4, No. 4, 231-283, December, 1931.

———"On Deep-focus Earthquakes in the Northern Part of Japan," *Ibid.*, Vol. 7, Nos. 3-4, 291-305, November, 1933.

———"On the Activity of Deep-focus Earthquakes in the Japan Islands and Neighbourhoods," *Ibid.*, Vol. 8, Nos. 3-4, 305-325, March, 1935.

[3] STECHSCHULTE, V. C., S.J., "The Japanese Earthquake of March 29, 1928, and the Problem of Depth of Focus," *Bulletin of the Seismological Society of America*, Vol. 22, No. 2, 81-137, Stanford, June, 1932.

[4] SCRASE, F. J., "The Reflected Waves from Deep-focus Earthquakes," *Proceedings of the Royal Society*, Series A, Vol. 132, 213-235, London, July, 1931.

———"The Characteristics of a Deep-focus Earthquake: A Study of the Disturbance of February 20, 1931," *Philosophical Transactions of the Royal Society of London*, Series A, Vol. 231, 207-234, London, 1933.

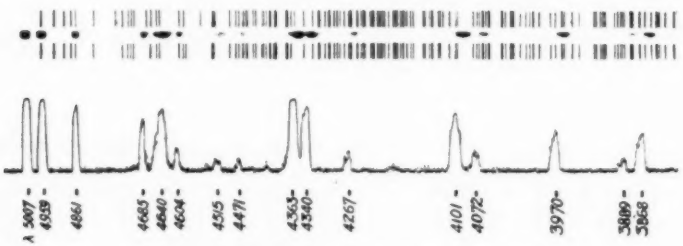
[5] BRUNNER, G. J., S.J., and MACELWANE, J. B., S.J., "The Brunner Focal Depth-Time-Distance Chart: A Graphic Chart for the Determination of the Focal Depth, the Time of Occurrence, and the Epicentral Distance from the Seismograms of a Single Station," John Wiley and Sons, New York, 1935.

Dominion Observatory,
Department of the Interior,
Ottawa, Canada,
January 9, 1936.

NOTE ON NOVA HERCULIS

By W. E. Harper

A PREVIOUS note* gave Journal readers some idea of the spectrum of the nova in its early stages after discovery in December, 1934. Inasmuch as our main spectrograph was out of commission at that time, due to the fact that the secondary mirror was being aluminized at Pasadena, we did not secure observations comparable to those at other observatories. They were, however, valuable in that the region in the ultra-violet which they covered is one that is not usually investigated.



SPECTRUM OF NOVA HERCULIS DEC. 2, 1935
SHOWING MICROPHOTOMETER TRACING.

The star slowly diminished in brightness from its maximum magnitude of 1.5 on 24th December, 1934 to a little fainter than magnitude 4.0 about the 1st of April, 1935. During the next three days it dropped about a magnitude per day and then more slowly thereafter until at the end of April it was down to about the 13th magnitude. About the 5th May it started to brighten up from its magnitude of 13.6 or thereabouts and continued increasing in brightness until the end of June when it was about magnitude 7.3. During the summer and autumn it continued around that brightness

A spectrogram taken on December 2nd, 1935 (Julian Date 2,428,139.602) with the short focus camera giving a dispersion of

*This Journal, February, 1935.

50 angstroms per millimetre at Hγ shows the spectrum as consisting almost wholly of isolated emission bands. It was felt that the publication of an enlargement of this plate with an accompanying microphotometer tracing would give Journal readers an idea of the present character of the nova's light. Unfortunately this article has been unduly delayed since requested by the Editor but it may yet serve a purpose.

The spectrum may be said in general to be similar to that of a planetary nebula. The strongest bands are the well-known nebular emissions N_1 (λ5007), N_2 (λ4959) and λ4363 due to trebly-ionized oxygen, the composite band at λ4640 due to doubly-ionized oxygen and nitrogen, and the hydrogen emissions. In the accompanying table are given the wave-lengths of the various emissions, the atoms giving rising to these and the displacements from the normal positions of the lines. For the most part the shifts correspond to

EMISSION FEATURES OF NOVA HERCULIS SPECTRUM 1935, DECEMBER 2

Emission &	Atom	Vel.	Arbitrary Scale		Area Angstroms
			Height	Area	
3868.74	Ne III	−82	35	37	3.9
3889.052	Hζ	−76	10	10	1.1
3970.075	Hϵ	−174	37	38	4.7
4072.2			18	17	2.5
4101.738	Hδ	−173	55	73	11.2
4267.16	C II	−67	13	15	2.8
4340.466	H	−71	62	56	11.7
4363.21	O III	−37	68	100	21.3
4412			4	5	1.1
4443			2	3	0.7
4471.477	He I	−157	10	8	1.9
4515.340	Fe II	−67	10	12	2.8
4604			24	18	4.4
4640	O II, N II		62	96	24.0
4685.74	He II	−61	51	40	1.0
4861.327	Hβ	−70	64	45	12.5
4958.91	O III	−112	68	74	21.1
5006.84	O III	−73	69	81	23.8
5754.8	N II		8	3	1.0

60 to 80 kms./sec. approach and for a few cases showing considerable departures from this value there is probably a valid reason. This velocity is that of the shell of gas surrounding the star. At this stage in the developments of the nova it is from this gaseous envelope that nearly all of the light comes.

Using a planimeter the areas of the line contours were determined on an arbitrary scale. These are shown in the fifth column of the table, the heights in arbitrary units being given in the fourth column. Considering the height of the N_1 (λ5007) line as unity the last column shows the equivalent areas in angstroms. While allowance was made for the varying dispersion no great accuracy is claimed; the aim being merely to get a rough idea of such areas.

THE ARCHITECTURE OF A STAR*

By R. M. Petrie

OUR purpose is to consider the information we possess regarding the structure of the sun and other stars. Such information leads to an understanding of the conditions prevailing inside the stars and, indeed, it is only through such an understanding that we shall arrive at the answer to the riddle of stellar life and evolution. Authoritative pronouncement upon the futures of the sun and earth is not possible until the plan of stellar architecture is clear.

At first sight, one might consider a study of the conditions prevailing inside the stars a hopeless task. We cannot reach out into the stars with our various probes and measuring devices, nor can we subject their material to chemical analysis. The chief weapon of the astrophysicist, the spectroscope, is powerless to deal directly with the problem—the brilliant glowing face of the sun masks very effectively the behaviour of the atoms, electrons, and light quanta below. To digress with a somewhat "earthy" allusion, the solar photosphere is the perfect "poker-face".

The spectroscope thus can observe only "skin-effects" in the stars. We wish to find out about such things as temperatures, pressures, densities, states of the atoms and liberation of energy. Until a short time ago astronomers were compelled reluctantly to agree with the dictum of Shakespeare when he wrote

> . . . the heaven's glorious sun
> That will not be deep-search'd with saucy looks.

This picture has been changed, however, and it is now possible for us to determine, with some assurance, what is going on below the stellar exteriors. A happy combination of observation and brilliant theoretical study has placed the subject upon a firm footing and has given us the hope that in the not too distant future we may understand something of why the stars shine and whence comes their tremendous store of energy.

Let us now pass to a consideration of a star as a subject for

*R.A.S.C. Lecture, Victoria Centre, Oct. 2, 1935.

experiment in order to see how we investigate its structure. Our tools in this case will be our instruments for the analysis of light and the laws of physics regarding the behaviour of matter and radiant energy at high temperatures. We proceed to formulate the problem as follows:

(1) The stars are mechanically stable.

(2) The stars are sources of radiant energy and hence the temperatures increase inward.

The first statement means that at all points throughout the star a balance is maintained between the various forces, for were this not so the stars would either collapse or blow up. We are, therefore, in a position to balance gravitation against the gas pressure and the pressure of radiation, throughout the star. Such information is valuable because it allows us to relate the density and the pressure throughout the stellar interior.

The second statement allows us to relate the pressure of radiation to position and density throughout the star. These two principles in connection with the laws of physics already referred to, allow us to solve the problem for a star of a given mass and surface temperature. Without going into the mathematical details we may say briefly that, given a star with a certain mass and temperature, it is possible to calculate the densities, pressures, and temperatures from the surface to the centre; to calculate the changes in the star's gravitation throughout its volume, and to get some idea of the conditions of the atoms under the extreme conditions prevailing in stellar interiors.

Before we consider a few examples of the application of this work we may well stop to ask ourselves, how do we know that these theories, resulting in a model of a star, are correct? In order to assure ourselves that we have not a purely hypothetical model we should find some observational check upon this. Fortunately such a test exists. One of the results of our theory is that, given the mass and surface temperature of a star, we can predict its brightness. There are many stars in the sky for which the masses, temperatures and luminosities are matters of observation. Comparison with the theory leads to quite satisfactory agreement and we can apply the results of our equations and feel fairly safe in the quantities which result.

We will now consider some typical cases and find out something about internal conditions in three stars. They are ordinary citizens of the sidereal community and are in no way exceptional. The first star is Capella, a giant star and one typical of its class. Next we have the sun which, as we all know, is a very average star, and finally we will examine the brighter component of a double star called Krüger 60, an example of the numerous class of red dwarf stars. The following table summarizes the knowledge we have regarding the physical properties of these objects from direct observation,—

TABLE I—Three Typical Stars

	Temperature °K	Mass × Sun	Diameter Miles	Luminosity × Sun
Capella	5200	4	10,000,000	100
Sun	5800	1	865,000	1
Krüger 60	3100	$\frac{1}{4}$	290,000	1/500

The columns in order represent the temperatures, masses in terms of the sun, diameters in miles and luminosities in terms of the sun. From the data given in the second and third columns we investigate the internal structure. Some of these results are shown in Table II, where the temperatures, densities and pressures age given for three points in the stellar interior.

From an examination of Table II one may form some idea of the conditions prevailing in stellar bodies and how these conditions change as we go toward the centre. Comparison with Table I will indicate how little the surface features inform us regarding the inner structure. The numbers arrived at seem very large and are, to some, incredible. They are by no means to be thought exceptional, however, and may be considered as representing the general run of stellar values. On our little cool particle we call the earth, we may now await the radiations coming to us from space, analyse them and apply our theories, and build up our models of the great gaseous infernos we recognize as the stars.

TABLE II—Internal Conditions in Three Typical Stars

	Temperature K	Density × Water	Pressure Atmospheres
	(a) At the Centre		
Capella	9,000,000	0.12	60,000,000
Sun	40,000,000	76.0	200,000,000,000
Krüger 60	32,000,000	490.0	1,000,000,000,000
	(b) Half-way to the Surface		
Capella	3,000,000	0.025	400,000
Sun	11,000,000	15.0	1,000,000,000
Krüger 60	9,000,000	100.0	7,000,000,000
	(c) Nine-tenths Way to the Surface		
Capella	300,000	0.00001	200
Sun	1,000,000	0.005	600,000
Krüger 60	1,000,000	0.03	3,000,000

THE ASTRONOMER LOOKS FOR LIFE IN THE HEAVENS*

By R. M. Petrie

THE question of the habitability of worlds other than our own, and in particular those nearest ours, the planets, has interested all classes of people from the early days of astronomical study. The contemplation of other worlds beyond our own, circling the same sun, undergoing seasonal changes and perhaps the abodes of living creatures impels us to transcend terrestrial matters and view our universe with a less anthropocentric bias. A popular interest in the question of planet habitation makes itself felt more clearly every year and the astronomer is assured of an attentive audience when discussing such a topic. The progress of scientific observation and interpretation increases steadily from year to year and we now find ourselves in possession of relatively new and accurate information regarding conditions on several planets. The topic is therefore a timely one and the general conclusions we can now draw are based upon trustworthy evidence.

Before we begin our search let us enquire into the conditions necessary to the existence of the thing we ordinarily call life. We must of course lay down some working definition of life and I shall assume that we agree on the usual attributes, *i.e.*, growth, mobility, assimilation, reproduction, decay, etc.—in other words anything that we should without hesitation pronounce alive, if met with on the earth, no matter how outlandish its form.

Anything in the nature of direct evidence is, of course, impossible to secure. The vast distances separating extra terrestrial bodies precludes examination of small objects upon their surfaces. For example Mars at its average distance from us looks about as large as a fifty-cent piece at a distance of half a mile. We must, therefore, attempt to study the conditions existing upon other worlds and from them base our ideas regarding habitability. The essential factors to be considered are:

(1) Food and Water Supply
(2) Atmospheric composition
(3) Climate (temperatures)
(4) Surface gravity.

---

*A lecture delivered at the First United Church, Victoria, B.C., Feb. 26, 1936.

We shall now proceed to inspect astronomical bodies in order to select suitable abodes of life. At the outset I must confess with true scientific caution, that you may to a large extent form your own opinions regarding the major part of the universe. The millions of stars of which we know, are similar to our sun in general, being sources of light and heat. But all are so far away that we have no hope of discovering planets attending them. For all we know, each star, and there are at least ten billions of them in our own local universe, may have a family of planets capable of supporting life. The scientific opinion on this point is based upon the indirect, although not necessarily inaccurate, results of mathematical statistics. According to our latest ideas on the matter solar systems are rare accidents—freaks among stars—and most stars drift through space, single, double or multiple, but usually without planets. Nevertheless, such is the profusion of stars that we might expect 100,000 solar systems in the universe of various ages and degrees of evolution. These possible systems remain completely beyond the power of our largest telescopes.

We are, therefore, restricted to our own small "corner" of space, the solar system. Can we study these planets, sister worlds to the earth, as they circle the sun and find a place where life may exist or develop? In addition to the earth we have the following objects to consider—the moon, Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. A brief survey of each will further narrow the search.

The Moon—Entirely unfit for life, being devoid of atmosphere and suffering extremes of temperature. For two weeks, day and night, it endures the pitiless glare of the untempered sun while the temperature reaches 300° F. and above. Then for a similar period it plunges into frigid night with the mercury at 300° F. below zero and colder. The clear cut visage of our satellite shows no trace of atmosphere, no water, and is lacking in all indications of the presence of life.

Mercury—Also unfit for life; a shrivelled and dried up planet near the sun, without air, without water and close to the central fire. One side of the planet continually faces the sun and is hot enough to melt lead, while the other half is exposed to perpetual night under the cold of space, being cold enough to freeze air solid.

Venus—A sister planet to the earth. This cloud-laden object offers some possibilities and will be discussed in more detail.

Mars—The planet most resembling the earth and the goal of most extra-terrestrial flights of fancy. This object may be considered a possibility.

The outer planets Jupiter, Saturn, Uranus, Neptune and Pluto may be discussed and dismissed together. They are all at vast distances from the sun with temperatures of a very low order $-150°$ F. to $-330°$ F. Their atmospheres are very dense and extensive and are found to consist, according to recent researches, largely of methane, ammonia and other noxious gases. If water is present it must be in the form of perpetual glaciers. It is well to point out that we can only observe the outer atmospheres of these objects. However, unless some unknown source of heat exists below in the plant's core, this picture is close to the truth.

The Case of the Planet Venus

This planet circling between us and the sun has been considered a possible abode of life. Similar in size and density, and therefore having the same surface gravity as the earth, possessing an atmosphere of considerable extent and enjoying an adequate amount of heat and light from the sun, it would seem favourably situated. Its year is 225 days long, its day is of the order of 20 terrestrial days, and the solar insolation is about twice that which we receive. Below its cloudy and dense atmosphere conditions similar to those existing here during mesozoic times may well exist. But we find upon examination with the spectroscope that oxygen and water vapour are absent and instead, vast quantitites of carbon dioxide are found. The absence of oxygen and the abundance of CO_2 are strong indications of the absence of plant life as we know it. Temperature measures indicate a warmer climate than the earth, somewhat of the order of our tropical regions. Until more conclusive evidence is at hand we must confess that Venus would be apparently unsuitable for habitation.

The Case of Mars

The planet Mars has long been considered the most suitable planet for life constituted as we know it. We find more definite

evidence in the case of Mars, as it is well suited for observation and its atmosphere is so rare and clear that we may distinguish its surface markings.

Mars revolves around the sun in a year of 687 days, has a day and night of almost the same duration as our own, and has its axis tilted so that its seasons and climatic zones resemble those of the earth. Its surface is characterized by broad orange coloured areas, smaller dark regions, narrow black streaks, spots and white polar caps. Well marked seasonal changes are observed as the Martian seasons progress. At the beginning of summer the sunward pole cap grows small and sometimes disappears, the dark areas deepen toward the equator, including the streaks and "sea" areas. Then as the fall and winter seasons approach, the dark areas fade away from pole to equator. Such seasonal changes are very reminiscent of the annual quickening and fading away of vegetative areas.

Mars has an atmosphere in which occasional storms, either cloud or dust, arise. Measurements have shown that it is very rare and desert like. Water vapour content is low, about 6% of that at high terrestrial altitudes (6400 ft.) and the oxygen supply is not more than 15% of that found at similar terrestrial elevations.

The temperatures of Mars have been relatively well determined. At the polar cap we find $T = -150°$ F., which gradually rises to $+32°$ F. at the date of the solstice. At the equator the temperatures at night are low but may rise as high as 60° F. during the day, or possibly a little higher. The planet is, therefore, colder than the earth, and of a desert like nature. We should find life very difficult there, but perhaps not impossible, if a generation or so were allowed for gradual acclimatization.

We have seen that most of the places in the universe, as far as we can examine them, turn out to be unsuitable for the support of life as we know it. The universe outside our solar system offers certain possibilities. We must remember that the measurements referred to are difficult to make and are not of extreme accuracy. The interpretation of surface conditions from measurements of atmospheric phenomena is a risky one and it would be rash to deny the existence of life in other worlds in the heavens. Regarding other stars and universes we must remember that time is just as limitless as space. There may be worlds where life has appeared,

reached a climax and disappeared, and there may be worlds where life will arise and expand into its wonderful variety. I cannot do better than conclude with a quotation from Sir Arthur Eddington upon the question. After reviewing the evidence we have discussed to-night, he says:—

"I do not think that the whole purpose of creation has been staked on the one planet where we live, and in the long run we cannot deem ourselves the only race that has been or will be gifted with the mystery of consciousness. But I feel inclined to claim that, at the present time, our race is supreme; and not one of the profusion of stars in their myriad clusters looks down on scenes comparable to those which are passing beneath the rays of the sun."

RADIO TALKS OVER CFCT, VICTORIA, B.C.

By W. E. Harper

No. 81.—THE CRUST OF THE EARTH

(April 16, 1935)

My last talk had to do with the atmosphere above us; the present one deals with the solid earth beneath our feet. I shall try to give an idea of its constituents and of possible changes taking place.

We find the earth's surface mostly covered with water, there being only about twenty-five per cent. of it land. We speak of it as land in the general sense, without distinguishing between soil and rock. In our childhood ideas there was a vast difference between soil and rock, but we come gradually to see that there is not much difference after all. The elements, such as wind and rain and frost, wear down even the hardest rocks, if given time enough, while many of the sandstones crumble very easily. The differing classes of soil, such as sandy or clayey, simply result from the difference in the rocks which give rise to them, while the black humus is decayed vegetable matter.

The depth of the soil proper is of course exceedingly small. Places there are where it amounts to hundreds of feet, but such are more than counterbalanced by extensive rocky areas totally devoid of covering, so that if the soil were spread uniformly over the earth's surface there would be a layer only skin deep.

Below this layer we have the continental rocks and below them we have reason to believe there are rocks of higher density still. It would seem, then, that there is a definite stratification of the materials at the earth's surface. First the atmosphere above us, then the waters resting in lakes upon the rocks or the covering of soil, then the continental rocks, averaging a density about 2.7 times that of water. Below these and the ocean depths we have evidence of rocks of higher density.

When we think of the suggested origin of the earth as having been thrown off from the sun while in a plastic if not gaseous condition, it is only reasonable to believe that the heavier elements would sink to the centre. The lighter elements would rise to the top and

give us the lighter rock mantle, surmounted again by the atmosphere itself.

The lighter rocks are known by the general name of granites, while the heavier ones, about 11 per cent. denser, are called basalts. In many parts of the world this heavy basalt covers vast areas of many thousands of square miles. How has it got there, since its logical home is miles beneath the continental structure of the granites? There seems no alternative to the theory that the interior has been at such a high temperature that these basalts have melted and in the fluid state have been squeezed up out of cracks or openings in the earth. The molten mass has then spread out to great distances before solidifying.

Examples of these outflows may be cited. The best known is the Giant's Causeway in northern Ireland, of which we have all seen pictures at least. Then there are what are known as the Deccan Traps, covering 200,000 square miles of the north-west of the peninsula of India, which is overlaid to an average depth of half a mile. In the Columbia river district outflows of these basalts cover 250,000 square miles and similar large areas cover Argentine, Brazil and even as far south as Patagonia.

These outflows have not been confined to any one particular period in the earth's history but have featured all geological eras from the earliest to the present. Moreover, all over the earth these lavas are strikingly alike in chemical composition. The density is uniformly 3.0, i.e., a volume of it has three times the mass of a similar volume of water. Such facts strongly support the view that these outflows come from a common reservoir underlying both oceans and continents.

The ocean floor may be considered as the upper surface of this substratum and there has, undoubtedly, been vast quantities of this basaltic lava poured on the ocean floor through fissures in its upper surface. Indeed, many of the islands are almost wholly basaltic in character with the same density and general character as the outflows covering the land. This is added proof of a common reservoir down in the earth.

I have stated that such flows have occurred in every age. Such a statement taken literally would give a wrong impression, as within

historical times I doubt if any such large-scale outpourings have been recorded. What was meant was that from time to time during the millions of years of the earth's history such flows occurred whose approximate dates can be read by the geologist from the rocks themselves. At present the substratum seems solid and the query comes to us: Will it ever become liquid again, and when?

It will. The earth's interior is gradually heating up and in due time further outflows will occur. We need not get in a panic, though, for it will not be in our day. Hundreds of thousands of years will elapse before the substratum will have reached the temperature of liquefaction.

What is the source of internal heat? It is a recent discovery and is no older than the discovery of X-rays. All rocks, granites or basalts are radioactive, that is, the heavier atoms constituting them, such as uranium and thorium, are continually disintegrating and this disintegration is accompanied by the production of heat. Such action is automatic; it does not seem possible to hasten nor retard it.

Uranium, the heaviest element, with atomic weight 238, changes eventually into lead with atomic weight 207. It might be thought that in the millions of years postulated for the earth's existence that it all would by now have been so transformed. Its rate of decay is so slow, however, that one-half of the present supply will not have disappeared for another 5000 million years.

The amount of heat produced by the radioactive process is to our earthly ideas infinitesimal. It would require a period of about 10^7 years for the process to effect a change of one degree in temperature in any given volume. While the temperature of liquefaction of basalt is 1150°C. it would not be necessary to heat the rock up to this temperature from zero. When the congealing has taken place the temperature has, of course, dropped, but one can imagine that the difference in temperature between solid and liquid states need no be excessive. If it were as much as ten degrees, then it would require 10×10^7, or one hundred million, years to change from one state to the other. During the earth's lifetime it has been estimated that at least five such great changes have taken place.

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

NEBULOUS METEORS

Two interesting reports concerning nebulous meteors have been received in answer to a request for such observations made by the writer a short time ago. Mr. E. P. Martz, Jr., Oak Park, Ill., an experienced meteor observer, gives an account of a nebulous meteor observed by him at 4.25 a.m. C.S.T., Nov. 14, 1934. It appeared about 5 degrees SE of Regulus and disappeared near β Cassiopeiae, behind some trees, traversing a path 100 degrees long in approximately 15 seconds. The meteor was elliptical in shape being slightly elongated in the direction of motion with a maximum diameter of 15 minutes of arc. It shone with a nebulous light slightly condensed in the centre and of a dull greenish shade, the similarity to a telescopic view of a planetary nebula being striking. There was no persistent train and no sound accompanying the phenomenon. A request in the newspapers for additional observations of this object elicited a report from an observer located about half a mile distant from Mr. Martz. This second observation, though made incidentally, agreed sufficiently well with the first in its essential details to verify the objectivity of the phenomenon, but the short baseline precluded the possibility of making a solution for height. Since the moon was absent from the sky and there were no bright lights or searchlights in the vicinity it seems probable that this object was meteoric in nature. Mr. Martz states that it is the only meteor of this type which he has noted in five years of observation.

The account of a similar observation comes from Mr. F. W. Smith of Glenolden, Pa. On Jan. 3, 1935, at 6.10 a.m. E.S.T. Mr. Smith observed a nebulous meteor of the third magnitude moving almost due north in Hercules from R.A. 262°, Dec. +13°, to R.A. 259°, Dec. +33°. The duration of flight was about 3 seconds and the angular diameter of the meteor 10 minutes of arc. This was the only nebulous object recorded out of 1700 meteors observed in 300 hours of observing time.

F. Baldet in L'Astronomie, vol. 23, p. 451, 1909, records in particular the data concerning seven nebulous meteors observed by himself and others, in addition to giving references to indicate that such objects have been generally noted by a number of trained meteor observers. The seven meteors described had apparent diameters varying from 5 minutes of arc to one or two degrees (in one case, made doubtful by the presence of cirrus, the extreme diameter recorded was 11 degrees). Their appearance was hazy and there was no evidence of a brilliant sharp nuclues like that of an ordinary meteor. The motion in some cases was quite rapid.

W. F. Denning, on page 277 of his book, "Telescopic Work for Starlight Evenings", describes a meteor which appeared first as a typical shooting star but which changed to a nebulous object in the course of its visible path without noticeably increasing in brightness.

There seems to be no doubt about the occasional appearance of these nebulous meteors. Their physical explanation is not very evident. The most striking feature recorded is the entire lack of brilliance in the luminosity produced, the visible radiation looking very much like that of persistent meteor trains. The observed diameters of nebulous meteors generally range from 5 to 30 minutes of arc and more rarely up to one or two degrees. This probably indicates real diameters of the order of 0.1 to 1.0 miles. Because of the hazy character of the light little of the apparent size can be ascribed to irradiation. It is practically certain, however, that before reaching the earth's atmosphere the nebulous meteor is but a small particle of matter as are the meteors of more normal appearance. It is necessary to account for the great increase in size when the meteor becomes visible.

Since, in the case of persistent meteor trains, we have rapid diffusion often resulting in a great extension in a few seconds, it is logical to assume a somewhat similar process operative in the nebulous meteors. We must, however, explain the absence of the bright concentrated luminosity present in the case of the ordinary meteor. It is known from meteor spectrum photographs that the violet and ultra-violet radiation of meteors is on occasion very intense in comparison to the visual radiation. In an extreme case of this kind the visible radiation might be so weak as to be negligible and

if there were a persistent train of short duration and definite termination it would simulate a so-called nebulous meteor. An elongation in the direction of motion, which is sometimes noted, would lend strength to this hypothesis. It might be argued that meteors with relatively strong ultra-violet intensity are likely to have a very high geocentric velocity and hence will not have the slow motion noted in the case of some nebulous meteors. In answer to this it must be remembered that in the first place we do not yet know enough about the exact process by which meteor luminosity is produced to be sure that high geocentric velocity is a prerequisite to strong ultra-violet intensity; and in the second place that the nebulous meteor may not move with the velocity of the unseen particle which produces it. It is conceivable that the hazy luminescence which forms the nebulous meteor appears after a greater time-lag near the end of the meteor's path than it does near the beginning. This would have the effect of making the apparent motion of the nebulous meteor slower. On the other hand it may not be necessary to assume the production of any radiation before the actual appearance of the nebulous meteor. The excitation producing the luminescence may be dispersed through atomic collisions.

The above remarks are intended merely as suggestions. There is no doubt that we have as yet far too little observational evidence to form any definite conclusions concerning the nature of nebulous meteors. When the phenomenon of persistent meteor trains is better understood we will be in a more favourable position to consider a theory of nebulous meteors. In the meantime a very complete record should be made by anyone observing such an object.

Two Bright Fireballs

Reports of two bright fireballs have been received recently. The first appeared near Winnipeg in the early morning hours of Feb. 16. Five reports of this meteor, received at radio station CKY, have been kindly forwarded by Mr. D. R. P. Coats, member of the Winnipeg centre. It was observed over a large section of Manitoba and also from northern Minnesota. Details concerning the exact appearance of the meteor are few but it must have been of great brilliance as it is described as throwing strong shadows and lighting up the distant landscape.

The second fireball was seen from southern Ontario at 7.55 p.m. E.S.T., Mar. 1st, 1936. It was apparently of rather unusual appearance having a bright nucleus surrounded by a hazy luminescence and followed by a short tail. All three reports received, without exception, described this object as a comet moving rapidly across the sky. It seems to have been somewhat nebulous and to have combined some of the properties of both normal and nebulous meteors. Additional observations of these two meteors are very much desired and may be sent to the writer at the Dunlap Observatory, Richmond Hill, Ont.

P. M. M.

REVIEW OF PUBLICATIONS

Stars and Telescopes by James Stokley. 319 pages, 5⅜ x 8½ in.; 33 pp. of "aquatones" of modern astronomical photographs, 31 line drawings and several facsimiles. N.Y. Harpers, 1936, $3.00.

Mr. Stokley is in charge of the astronomical division of the museum of the Franklin Institute in Philadelphia, which includes the Zeiss planetarium provided by Mr. Fels. He states that, being continually asked to recommend a book to carry forward the instruction given to visitors and there being none just to his taste, he undertook to produce one. It is an excellent work.

There are 22 chapters. Those dealing with the improving of the telescope are exceptionally good. The author is well informed and numerous interesting facts are given which are seldom—or never—found in histories of astronomy. Many of the details related possess the peculiar interest to personal interview and investigation. The style is vigorous and the language clear. Practically all branches of astronomy are touched upon, including the perennially interesting question of life in the universe.

In the frontispiece is a photograph of the 74-inch reflector of the David Dunlap Observatory directed to the sky, taken by the author. There is a good bibliography for the amateur, a glossary of technical terms used and an index.

C. A. C.

Let's Look at the Stars by Edwin Brant Frost. 118 pages 5¾ x 8 inches, 5 figures and 29 plates. Houghton Mifflin Company, 1935. Price $2.00.

The author is the late E. B. Frost, for many years director of the Yerkes Observatory. This is not a book written for astronomers but for boys and girls of twelve to fifteen years. While he comes down to the level of their scholastic attainments, yet he finds language to convey clearly the most involved ideas connected with the subject and many an astronomer could profit by reading the book to see how simply modern ideas of the Universe can be presented.

It is dedicated to a young friend, Richard Crane Bradley, whose interest in the stars led to the writing of the book. We can easily guess who created the interest in the first place, for Frost, though blind in the closing years of his life, treasured memories of the star groups which he made very real to the young people in whose company he took great delight.

The matter of the book is given in twenty-nine chapters, each of which deals with a single subject and is complete in itself. The chapters are short, only three or four pages to each on the average, and being printed on excellent paper in fairly large type, each chapter can be read in a few minutes. One delights to ponder over the illustrations for the book is copiously illustrated from photographs made at the Observatory over which he presided so long.

We learn about the Sun and the Moon, eclipses, planets, comets, meteors and the constellations. His chapter on the variable stars, the nebulae, the clusters and spirals are a triumph of clear and interesting explanation. Incidentally, his book is full of fascinating information on observatories, telescopes and the methods of studying the skies.

W. E. H.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Not a Foreign Country

The present writer had planned a motor trip to Florida, but about January 20 a period of near-zero weather set in, with snow and blow, and departure was not feasible for a month. However a warm wave arrived about February 22—coincidentally, so it is said, with a change of the moon!—and a start for the south was made on the 26th.

The temporary rise in temperature together with a shower of rain had partially loosened the ice which had so grown that it almost completely stopped the flow over the American side of the Niagara Falls, while the accumulation of ice in the river had seriously injured power development schemes and some docks a few miles farther down. While viewing the Falls a kindly taxi-driver asked the "young fellow", as he dubbed the traveller, if he was going through New York State and advised him not to go too fast around the curves. Several small snow-falls did not prevent continued progress.

A stop at Corning enabled one to hear an interesting address by Dr. W. W. Shaver, of the Glass Works, on the researches made during the last five years into a new type of "Pyrex" glass which may be subjected to far severer use, both thermally and mechanically, than ordinary pyrex ovenware. Dishes were used for the hardest kinds of cooking. A dish was heated to a high temperature and thrown into water, and also dropped from a height of over twelve feet, without breaking.

The great 200-inch disc of glass for the California Institute of Technology was found securely packed in a steel case, lined with sponge rubber, and with lugs and trunnions bolted on it for convenience in handling. The glass weighs about twenty tons and the case some sixteen more. When being transported by the railways the disc will be held in a vertical position on a steel car constructed specially for the purpose. The case is 17 ft. ½ in. in diameter and it will be supported on the car 6 in. above the steel rails. The greatest

height of the overhead bridges above the rails which could be secured was 17 ft. 10 in., so that the clearance under some bridges will be only 3½ inches. A portion of a building has been cut away to allow the disc to be moved from its room to the railway car. Last August when a "cloudburst" struck upper New York state and did immense damage to several towns, the waters of the Chemung River at Corning rose until they immersed the transformers of the annealing kiln and indeed were only about six feet from the disc itself.

Just when this precious jewel, still in the rough, will leave Corning, or the route it will follow to Pasadena, has not been announced. On reaching that place it will once more be turned horizontal and transported to the optical shops of the California Institute. Then will begin the process of grinding and polishing it. Such a mighty task has never before been attempted.

From Richmond, Va., (March 2) southwards, the weather was quite warm, although snow could still be seen, but the early birds were singing and trees and flowers were coming into bloom. Through the Carolinas, Georgia and Florida the roads in general were straight, level, and well-surfaced. Frequently they led through wide cotton fields or impressive swamps full of water, a great viaduct having been built up to carry the pavement. There were few notices of speed limits. The result was that most of the cars travelled faster than they do in Ontario, and the astronomer was left behind. Moreover he wished to observe the country. Only one mishap came under the writer's notice. A small car which some minutes before had swept by at a high speed was observed in the ditch and skid-marks a hundred yards long could be seen on the pavement. A friendly truck was trying to pull the car back to the road.

At a town in Southern Georgia one passes a large oil refinery but it must be acknowledged that the odour which comes from it is far from refined. In this place the very courteous service station attendant, after filling the gas-tank, wished to know if he could do anything further for "the captain". A little farther south the generous hostess at the table expressed anxiety to provide further good things for "the boy". At an old-fashioned hotel facing the ocean, in a bookcase in a wide hall, were *Caesar's Gallic War* (Harper and Tolman) and *Sallust—Literally Translated;* and among ten thousand auto-

mobiles which covered a famous beach on the east coast,—many gathered to see the motor-car races—were three bicycles "built for two", each propelled by a man and a woman! A person who travelled about the country and lived in one of those familiar trailers informed the writer that he had seen every part of the United States and Canada, east and west, and insisted that one cannot say that he has seen Florida until he has seen Miami,—that this beautiful city is the embodiment of the spirit of the modern state. However it had to remain unvisited this year. There is more than enough to lure one back to this sunny land again.

C. A. C.

ERROR IN THE 1936 *HANDBOOK*

An error on page 64 of the *Handbook* has been noticed by Mr. Merritt A. Brown. The absolute magnitude M, of the star Ross 248, should be changed from 14.3 to read 16.3, and the luminosity L, from 0.0002 to 0.00002 times that of the Sun.

MEETINGS OF THE SOCIETY

AT TORONTO

December 3, 1935.—A regular meeting of the Toronto Section was held at 8.00 p.m. in the McLennan Laboratory of the University of Toronto; A.R. Hassard in the Chair.

A Nominating Committee, consisting of Dr. Lachlan Gilchrist, Dr. R. K. Young, J. H. Horning, and J. R. Collins was appointed to nominate officers of the Toronto Section for 1936.

Two persons were elected as Members of the Toronto Section, namely:

Mr. Albert W. Irving, 44 Hastings Ave., Toronto; Mrs. S. S. Nicolson, 24 Mill St., Lindsay, Ont.

Dr. C. A. Chant then addressed the meeting, speaking on the recent meeting of the International Astronomical Union in Paris. The I.A.U., which was organized under the auspices of the International Research Council, first met in Rome in 1922, and since has met at three year intervals in Cambridge, England; Leiden; Cambridge, Mass.; and Paris. The Paris meeting was held under the presidency of Prof. Frank Schlesinger of Yale University, from July 10 to 17, twenty-seven countries being represented among the delegates.

Dr. Chant told of the meetings of the many "commissions" or committees of the Union which dealt with problems of astronomical research, and also spoke about the various social functions which were arranged by the French Government and astronomers for the entertainment of their visitors.

December 17, 1935.—A regular meeting of the Toronto Section was held at 8.00 p.m. in the McLennan Laboratory of the University of Toronto. In the absence of the Chairman, the Vice-chairman, E. J. A. Kennedy presided.

Three persons, proposed for membership at the previous meeting, were duly elected to membership in the Society:

Toronto Section: Mr. F. K. Dalton, 286 Willard Ave., Toronto. *Members-at-Large:* Mr. R. J. Douglas, Moorefield, West Virginia; Mr. Philip Fortier, Kankakee, Illinois.

Two candidates were nominated for membership in the Society:

Toronto Section: Mr. Charles G. Ashley, 81 Bloor St. West, Toronto; *Members-at-Large:* Mr. Robt. B. Dumbarton, Pikesville, Maryland.

On motion of S. C. Brown, the rule set forth in By-law II was suspended, and these candidates were duly elected to membership.

Miss E. M. Budd reported that during the previous five months, 230 periodicals had been received in the library and that 27 volumes had been bound and sent to the Dunlap Observatory. Mr. S. C. Brown called attention to the fact that members in other centres were writing for information about their proposed amateur telescope group.

Mr. Brown outlined the winter constellations on a slide illustration. J. R. Collins spoke on the surface features of the moon and illustrated his remarks with slides.

Professor G. R. Anderson spoke briefly on motion picture colour photography, and then showed a film in natural colour prepared by the "Kodachrome" process. "Apparently it will never be possible to take pictures in colour with the same simplicity as we take them in black and and white," he said in explaining the involved technique of colour photography.

December 17, 1935.—The annual meeting of the Toronto Section was held in the McLennan Physics Laboratory immediately at the close of the regular meeting. E. J. A. Kennedy was in the Chair.

The minutes of the annual meeting for 1934 were taken as read.

The Secretary's report was presented by S. C. Brown. The membership was 177 as compared with 174 in 1934, a gain of 3 members. During the year 26 new members were elected and 23 resigned. A list of the speakers at the meetings during 1935 was read. Moved by J. E. Maybee, seconded by Miss F. S. Patterson, that the Secretary's report be accepted. Carried.

The Treasurer's report as presented by J. E. Maybee, and accepted by the meeting, has appeared in the March number of this Journal.

The report of the Nominating Committee was presented by J. R. Collins. Officers for 1936 were elected as follows:

Hon. Chairman, Dr. C. A. Chant; *Chairman*, A. R. Hassard; *Vice-chairman*, E. J. A. Kennedy; *Secretary*, S. C. Brown; *Recorder*, Miss F. S. Patterson; *Treasurer*, J. E. Maybee; *Curator*, R. S. Duncan; *Council*, Dr. D. S. Ainslie; Dr. L. Gilchrist; F. L. Harvey; Dr. F. S. Hogg; J. H. Horning; Dr. P. M. Millman; T. H. Mason; Rev. C. H. Shortt; Dr. R. K. Young; and *Past-chairmen*, A. F. Hunter; J. R. Collins; R. A. Gray.

FREDERICK L. TROYER, *Recorder.*

February 18, 1935.—The regular meeting of the Toronto Section was held in the McLennan Laboratory, with Mr. A. R. Hassard in the Chair.

The new order of procedure, as drawn up by the Council for the Toronto Section was inaugurated. It is as follows:

1. Chair is taken at 8 o'clock
2. Minutes
3. Election of new members
4. Nomination of new members
5. Paper of the evening
6. Notes and Queries
7. Observations
8. Prediction of Phenomena
9. Any other business
10. Announcements

The minutes of the last regular meeting, December 17, 1935, were read and adopted.

Eleven persons were nominated to membership, namely:

Toronto Section: Dr. J. F. Heard, Richmond Hill, Ont.; Miss G. M. P. Taylor, Thorold, Ont.; Mr. L. J. Butler, Chicago, Ill. *Members-at-Large:* Mr. R. Baldock, Blacksburg, Va.; Mr. J. L. Hinds, Rio Grande, Tex.; Mr. W. G. Worley, Mayfield, Australia; Mr. L. G. Stoddard, Berkeley, Calif.; Mr. R. A.

Holsinger, Hallidaysburg, Pa.; Mr. J. C. Meyer, Cudahy, Wisc.; Miss J. Babcock, Denver, Col.; Mr. C. O. Arthur, Washington, D.C.

The paper of the evening was "Eclipsing Binaries", presented by Dr. J. F. Heard, M.A., Ph.D. of the Astronomy Department of the University of Toronto. The lecture was illustrated with slides and models. Binaries may be classified into three different sections, *e.g.*, visual, spectroscopic and eclipsing. The lecture dealt with each, dwelling mostly on the latter two. In the case of the visual binaries, the observer can plot from observations the apparent orbit. From this he can obtain the elements of the true orbit. These elements contain the masses of the two stars, if the binary permits its centre of gravity to be determined.

The spectrograph gives information of other binaries not resolvable in the telescope. From the spectrograms of such stars, A radial velocity can be determined. However, this curve does not give absolutely the size of the orbit or the masses of the components. These come out multiplied by the sine of the angle of inclination. However if the inclination is approximately equal to 90 degrees, we get one star coming in front of the other to form an eclipsing pair. The light curve of such a pair gives information as to the relative luminosities of the components, their diameters in terms of the size of the orbit, and the inclination.

Thus if the spectroscopic orbit of such a pair is also known, the size of the orbit, and the masses and densities of each of the pair can be absolutely determined. This is the only direct method of measuring the density of a star.

Dr. Heard also mentioned two interesting areas. ζ Aurigae, whose eclipse in 1934 gave the information that it was surrounded by a huge atmosphere showing rotation, and 29 Canis Major, which, according to a clipping, is 70 times as heavy as the sun, making it the heaviest star known.

The lecture was followed by a discussion on the paper and on allied topics.

There being no reports of observations due to unsatisfactory weather, the meeting adjourned.

F. S. PATTERSON, *Recorder.*

AT VANCOUVER

December 10, 1935.—The 35th regular meeting was held in the Science Building of the University of B.C. on Tuesday, December 10th, 1935. Professor W. H. Gage, M.A., presiding.

After the Secretary's and Treasurer's report of activities and financial standing had been read the members considered the list of 1936 officers ballotted for and approved the election.

Members then adjourned to the Physics and Optics laboratory where representatives of the Physics department gave the following demonstrations:

Newton's rings as the first method of producing interference.

Fresnel's biprism as a more accurate method for measuring wave-lengths.

Michelson's interferometer as a standard for wave-lengths and as used to test the theory of relativity.

The bright line arc spectrum of copper showed the use of the spectroscope, as being one of the most powerful weapons of the modern astrophysicist.

These demonstrations were carried out by Mr. R. F. Christy, assistant in Physics.

Dr. Ure for the Chemistry department provided the following demonstrations:

Brownian movement in smoke particles—using a Leitz dark field condenser.

Chemiluminescence—the oxidation of 3-amino-phthal hudrazide—a reaction producing cold light.

Flame spectra of the elements.

Absorption spectrum of rare earth salts in solution.

Line spectra of neon and argon.

C. A. McDONALD, *Secretary.*

January 14, 1936.—The 36th regular meeting was held in the Science Building of the University of B.C. at 8.15 p.m., Mr. C. A. McDonald presiding.

Mr. H. P. Newton gave a very interesting talk on the "Stars of the Month" calling the attention of the members to the position of the various winter constellations with the assistance of slides, and giving details of the various outstanding stars for the month, reference being made to the fact that the planets were not in a good position for observation during January.

Before introducing the speaker of the evening, the president referred to a request made by the Executive Headquarters in Toronto for an expression of opinion from the Vancouver Centre regarding the use of membership cards. It was moved that this matter be referred to the council for their decision.

Mr. McDonald then introduced the speaker of the evening to the meeting, Dr. D. C. B. Duff of the University of B.C. Dr. Duff's subject was "Laboratory Methods in Bacteriology".

The speaker opened his lecture with an explanation of the various forms of bacteria which were described as minute, single-celled forms of plant life ranging in size from 200mμ to 3μ depending on the species. The commonest forms are rod (bacterium, bacillus), spiral (vibrio, spirillum) and spherical (coccus). Individual bacteria under nutrient conditions will grow into colonies which are plainly visible to the naked eye and which vary in form according to the species.

The special laboratory methods used in studying such micro-organisms rest chiefly upon the means for sterilizing and maintaining in a sterile condition the various apparati employed, so that one bacterial species may be studied in pure culture. Demonstrations of laboratory methods were given.

Most bacteria are visible and measurable by magnification methods employing white light, but living particles (viruses) have been demonstrated and measured below the level of 200mμ by the use of ultra-violet light photography. The size of living particles too small for measurements of this type may be estimated by passing through porcelain filters or collodion ultrafilters of known porosity, under controlled conditions of temperature, pressure, and electrical charge on filter and on particles.

It was pointed out that the distinction between viruses and bacteria may at least in part be an artificial one, depending on the limit of resolvability with white light. For instance, *Bacterium pneumosintes* while just visible by optical

systems using white light, is also capable of passing through porcelain filters which restrain practically all other bacteria.

Many bacteriological determinations in the fields of sanitation and experimentation call for a knowledge of the number of individual bacterial cells present at a given moment in a fluid suspension. Means for obtaining such counts include: direct counting of stained bacteria in known volume of fluid (Helber counting chamber); estimation of the live bacterial content per unit volume by the dilution method, with reference to "most probable number" tables; and estimation of the number of living bacteria by suitable dilution followed by plating on a solid medium in a Petri Plate, with subsequent counting of the colonies formed from the individual cells.

The common statistical and biological errors inherent in such means of estimation were pointed out and the precautions required to minimize these errors were described.

Slides of various cultures of bacteria were shown and also practical demonstrations of how the cultures were prepared and transferred to sterilized laboratory utensils were given by Dr. Duff, closing his interesting lecture with a display of microscopes in use to-day, and also types of bacteria microscopes in use before the modern types were developed.

A number of questions were asked and answered by Dr. Duff to the satisfaction of those making the enquiries and after a hearty vote of thanks the meeting adjourned.

J. H. Moore, *Secretary.*

The Royal Astronomical Society of Canada

OFFICERS FOR 1936

Honorary President—THE HON. LEONARD SIMPSON, M.D., Minister of Education for the Province of Ontario.
President—R. E. DELURY, M.A., PH.D., Ottawa.
First Vice-President—WM. FINDLAY, PH.D., Hamilton, Ont.
Second Vice-President—J. A. PEARCE, M.A., PH.D., Victoria, B.C.
General Secretary—E. J. A. KENNEDY.
General Treasurer—J. H. HORNING, M.A., Toronto.
Recorder—E. J. A. KENNEDY, Toronto.
Librarian—P. M. MILLMAN, PH.D.
Curator—R. S. DUNCAN, Toronto.
Council—D. S. AINSLIE, M.A., PH.D., Toronto; F. NAPIER DENISON, Victoria, B.C.; MISS A. VIBERT DOUGLAS, PH.D., Montreal; E. A. HODGSON, M.A., PH.D., Ottawa; DR. G. R. MAGEE, London, Ont.; J. EDW. MAYBEE, Toronto; P. M. MILLMAN, PH.D., Toronto; A. THOMSON, M.A., Toronto; JOHN SATTERLY, M.A., D.Sc., Toronto; L. A. H. WARREN, M.A., PH.D., Winnipeg; and Past Presidents—SIR FREDERIC STUPART; C. A. CHANT, M.A., Ph.D.; A. T. DeLURY, M.A.; L. B. STEWART, D.T.S.; J. S. PLASKETT, D.Sc., F.R.S.; A. F. MILLER; J. R. COLLINS; W. E. W. JACKSON, M.A.; R. M. STEWART, M.A.; A. F. HUNTER, M.A.; W. E. HARPER, M.A.; H. R. KINGSTON, M.A., Ph.D., R. K. YOUNG, M.A., Ph.D.; L. GILCHRIST, M.A., Ph.D. and the presiding officer of each Centre.

TORONTO CENTRE

Honorary Chairman—DR. C. A. CHANT
Chairman—A. R. HASSARD, K.C. *Vice-Chairman*—E. J. A. KENNEDY
Secretary—S. C. BROWN, 22 Kings Lynn Rd., Etobicoke, Ont.
Recorder—MISS F. S. PATTERSON *Treasurer*—J. E. MAYBEE
Council—DR. D. S. AINSLIE; DR. L GILCHRIST; F. L. HARVEY; DR. F. S. HOGG; J. H. HORNING; T. H. MASON; DR. P. M. MILLMAN; REV. C. H. SHORTT; DR. R. K. YOUNG; and the Past Chairmen—A. F. Miller; A. F. Hunter, and J. R. Collins.

OTTAWA CENTRE

Honorary President—R. GLENN MADILL *President*—A. H. MILLER
First Vice-President—J. McLEISH *Second Vice-President*—MISS M. S. BURLAND
Secretary—M. M. THOMSON, Dominion Observatory *Treasurer*—A. W. GRANT
Council—DR. A. WILLARD TURNER; DR. E. A. HODGSON; W. F. MATLEY; W. J. SYKES; KARL BUCKTHOUGHT; and all Past Presidents

MONTREAL CENTRE

Honorary President—MGR. C. P. CHOQUETTE *President*—GEO. R. LIGHTHALL
First Vice-President—DR. JULIAN C. SMITH *Second Vice-President*—F. DE KINDER
Secretary-Treasurer—DR. A. V. DOUGLAS, Physics Building, McGill University
Council—DR. A. N. SHAW; COL. W. E. LYMAN; G. HARPER HALL; DR. L. V. KING; DR. C. C. BIRCHARD; O. A. FERRIER; H. F. HALL; E. R. PATERSON; J. A. REID

LONDON CENTRE

Honorary President—DR. H. R. KINGSTON *President*—MAJOR E. H. ANUNDSON
Vice-President—D. M. HENNIGAR *Treasurer*—DR. H. S. WISMER
Secretary—DR. G. R. MAGEE, 427 William St.
Council—MISS S. LIVINGSTONE; MISS M. TORY; T. C. BENSON; REV. R. G. BOWEN; L. G. PLANQUES

WINNIPEG CENTRE

Honorary President—DR. J. S. PLASKETT *President*—A. V. PIGOTT
First Vice-President—W. H. DARRACOTT *Second Vice-President*—J. H. KOLB
Secretary—MISS K. ST. JOHN, Ste. 4, Rideau Hall *Treasurer*—R. D. COLQUETT
Council—L. T. S. NORRIS-ELYE; M. F. BENNETT; G. P. MORSE; W. R. JUNKIN; P. H. STOKES; MRS. A. S. WILLIS

VICTORIA CENTRE

Honorary President—H. BOYD BRYDON
President—LIEUT.-COMDR. H. R. TINGLEY *Vice-President*—ROBERT PETERS
Secretary-Treasurer—GORDON SHAW, 1010 Hampshire Rd. *Librarian*—MIRA OLIPHANT
Council—A. I. DEACON; W. R. HOBDAY; L. HOPKINS; ANDREW MCKELLAR, PH.D.; R. M. PETRIE, PH.D.

HAMILTON CENTRE

Honorary President—MRS. D. B. MARSH *President*—PROF. A. E. JOHNS, PH.D.
First Vice-President—T. H. WINGHAM *Second Vice-President*—G. CAMPBELL
Third Vice-President—W. T. GODDARD *Curator*—T. H. WINGHAM
Secretary-Treasurer—NORMAN GREEN, 186 Rosslyn Avenue N.
Council—DR. W. FINDLAY; J. A. MARSH; W. S. MALLORY; G. FREEMAN; REV. E. F. MAUNSELL; J. S. TAYLOR; S. W. SCAMMELL; MRS. SCAMMELL; E. E. BOSSENCE; H. ALDOUS; N. H. BROADHEAD.

VANCOUVER CENTRE

Honorary President—DEAN D. BUCHANAN, M.A., PH.D., LL.D.
President—C. A. MACDONALD *First Vice-President*—H. P. NEWTON
Second Vice-President—MRS. LAURA ANDERSON
Secretary—J. W. MOORE, 2505 10th Avenue W. *Treasurer*—A. OUTRAM
Council—SETO MORE; M. A. MCGRATH; D. L. SHAW; G. E. FROSTRUP; J. C. JORGENSEN; J. W. PICKEN; H. A. PITMAN; S. RICHMOND; J. DONALD; and Past Presidents

EDMONTON CENTRE

Honorary President—DR. J. W. CAMPBELL *President*—F. S. SIMPSON
Vice-President—J. G. TAYLOR *Treasurer*—E. N. HIGINBOTHAM
Secretary—E. S. KEEPING, University of Alberta
Council—JOHN BLUE; MISS M. O. BUCHANAN; R. CHAMBERS; DR. E. H. GOWAN

CALGARY CENTRE

President—HAROLD C. KING *Vice-President*—H. J. REES
Secretary-Treasurer—G. FINLAY MOORE, 3206 Vercheres St.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

This Society was incorporated in 1890 under the name of The Astronomical and Physical Society of Toronto, and assumed its present name in 1903.

The Society has active Centres in Montreal, P.Q.; Ottawa, Toronto, Hamilton, and London, Ont.; Winnipeg, Man.; Edmonton, Alta.; Vancouver and Victoria, B.C.

The Society publishes a monthly JOURNAL containing each year about 500 pages and a yearly OBSERVER'S HANDBOOK of about 80 pages. Single copies of JOURNAL or HANDBOOK are 25 cents.

Membership is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00. Publications are free to members, or may be subscribed for separately. Apply to the General Secretary, 198 College St., Toronto, or to the local secretary of a Centre.

Extract from the By-Laws: Candidates who are elected to membership will be attached to a particular Centre, or to a section known as *Members at Large*. Members of the Society who live outside of Canada, or in a province in which there is no Centre of the Society will be considered *Members at Large* and not attached to any particular Centre, unless these members are expressly nominated for membership and attachment to a particular Centre. Members may be transferred from one Centre to another, or to the section *Members at Large* by the Council of the Society if written application for such transfer is made by such member to the Council.

The Society has for Sale:

General Index to the TRANSACTIONS of the R.A.S.C., 1890-1905, and the JOURNAL, Vols. 1 to 25, 1907-31.

Compiled by W. E. Harper, Assistant Director, Dominion Astrophysical Observatory, Victoria, B.C.

Pages, 122; Price, $1.00, postage 5c. extra.

New Materials for the History of Man—The Festival of the Dead, by R. G. Haliburton.

This is a research into the Year of the Pleiades, first published at Halifax, N.S., in 1863; reprinted by the R.A.S.C. in 1920.

Pages, 126; Price, $1.00, postage 5c. extra.

Send Money Order to 198 College St., Toronto.